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Development of LED Light Sources for Improved Visualization of Veins: a statistical approach

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***Abstract*—The present statistical study investigates the difference of diffuse reflectances between skin and vein (defined as contrast indicator) under different visible wavelengths of a population of 39 adult participants. The purpose of the study is to examine if there is a group of wavelengths-color combinations that could explain most of the variance (of the contrast indicator) in the data set. Moreover the effect of gender and age on the contrast indicator is explored.**

Keywords— Principal component analysis (PCA); LED; vein visualization;

I. INTRODUCTION

The present study is a part of a larger effort concerning improved visualization of biosamples by applying a special illumination source constructed by light emitting diodes (LED)[1]. The current biosample consists of human skin and vein at the wrist region. The fewer wavelengths used for achieving a good contrast (assumed to be equivalent to contrast indicator) the more economic and environmentally friendly the light source is. LED light sources allow almost full control over the wavelengths that are emitted and that opens new possibilities for enhancing the contrast of specimens in a cheap way, by choosing only the wavelength combination that maximizes the contrast for the majority of the population. In order for the concept to make sense, the first thing that needs to be investigated and analyzed is if human vein to skin contrast is similar for a population of people. If at some wavelength combinations the vein-skin contrast varies drastically among a population of people it makes no sense to include these wavelengths in an illumination source designed for optimal visualization of veins. It is known that skin pigmentation of humans varies worldwide, and vein structure (diameter, depth in the skin etc) also differs from person to person. To our knowledge the contrast (in terms of diffuse reflectance) between veins and skin for a population of people, at different combinations of wavelengths or colors, has not previously been reported.

II. RESULTS

Results from a PCA analysis showed that 87.7% of the variance of the data is explained by the first principal component (PC1). All colors have positive and similar sized loadings for PC1 (Fig.1), with yellow contributing most and blue contributing least to this component; explaining 87.7% of the variance. Another interpretation is that the intensity level of the contrast indicator is the parameter that explains most of the variance in the dataset. A high intensity level of the contrast indicator should be perceived as very visible veins under all wavelengths, and are located at high values of PC1 (Fig. 1), and so one could easily identify persons with highly visible veins. 6.2% of the variance of the data is explained by the second principle component (PC2). PC2 involves the distribution (shape of the spectral curve); opposing orange/red to violet/blue. Yellow and green color contribute only very little to PC2. No difference in response or special grouping of the contrast indicator due to gender or age was observed for PC1 or PC2. The explained variance of each of the colors was above 90% in all cases.

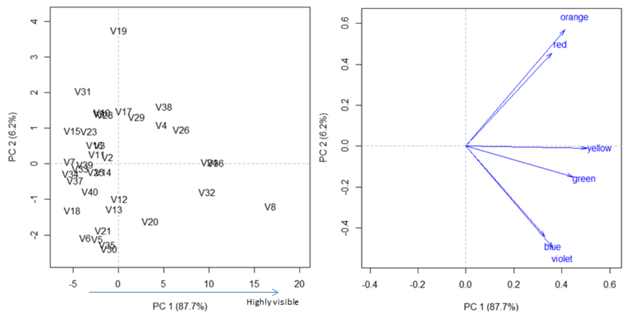

Fig. 1. PCA analysis graph, performed with colors as variables. Points interpreted as bad leverage points were removed from the sample.

III. SUMMARY

It is shown that yellow is the color that contributes most to the variations of vein-skin contrast among a population of 39 samples, while blue is the color which contributes least to the variation of the contrast. Moreover, no grouping of contrast response due to gender or age was observed for any of the visible wavelengths applied.

REFERENCES

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